CLAIMS

[1] A data transmission method for a transmission apparatus of transmitting a plurality of data sequences from a plurality of transmission antennas to a plurality of reception antennas using MIMO-OFDM, the method comprising the steps of:

dividing a synchronization symbol in which predetermined amplitudes and phases are assigned to a plurality of subcarriers which are spaced at predetermined frequency intervals and are orthogonal to each other, into the plurality of transmission antennas, to generate a plurality of synchronization subsymbols; and

converting the plurality of synchronization subsymbols into radio signals, and simultaneously transmitting the radio signals from the plurality of transmission antennas.

[2] The data transmission method according to claim 1, further comprising:

modulating a plurality of pieces of transmission data to be transmitted from the plurality of transmission antennas into a plurality of data symbol sequences; and

generating propagation coefficient estimation symbols orthogonal between each of the transmission antennas as symbols for estimating inverse functions of propagation coefficients possessed by a plurality of transfer path between the transmission antennas and the reception antennas,

wherein the converting and transmitting step includes:

multiplexing the data symbol sequence, the synchronization subsymbol, and the propagation coefficient estimation symbol into a transfer frame for each of the plurality of transmission antennas; and

converting the transfer frame multiplexed for each of the plurality of transmission antennas into a radio signal.

[3] The data transmission method according to claim 2, wherein the step of modulating into the data symbol sequence includes:

generating a data carrier by applying an amplitude and a phase based on the transmission data to a predetermined one of the plurality of subcarriers;

generating a pilot carrier by assigning a known phase and amplitude to a subcarrier other than the data carrier; and

orthogonally multiplexing the data carrier and the pilot carrier into a plurality of data symbols, and outputting the plurality of orthogonally multiplexed data symbols as the data symbol sequence.

[4] The data transmission method according to claim 3, wherein, in the step of generating the pilot carrier, a known phase and amplitude are assigned as the pilot carrier to only one of data symbols to be simultaneously transmitted from the plurality

of transmission antennas, and an amplitude of 0 is assigned as the pilot carrier to the other data symbols to be simultaneously transmitted.

[5] The data transmission method according to claim 1, wherein, in the converting and transmitting step, in order to achieve synchronization between the plurality of transmission antennas, a single transmission local oscillator common to the transmission antennas or a plurality of transmission local different among the transmission antennas, are used.

[6] A data reception method for a reception apparatus of receiving a plurality of data sequences transmitted from a plurality of transmission antennas using MIMO-OFDM, via a plurality of reception antennas, wherein

the plurality of data sequences include synchronization subsymbols generated by dividing a synchronization symbol composed of a plurality of subcarriers orthogonal to each other into the plurality of transmission antennas,

the method comprising the steps of:

receiving the plurality of data sequences for each of the reception antennas;

synchronizing and demodulating the data sequences received by the plurality of reception antennas for each of the reception antennas; and

estimating characteristics possessed by a plurality of transfer paths between the transmission antennas and the reception antennas, for each of the transfer paths, based on the received signal demodulated for each of the reception antennas and the synchronization subsymbol included in the received signal.

[7] The data reception method according to claim 6, wherein the step of estimating the characteristics for each of the transfer paths includes estimating a frequency error occurring in each of the transfer paths from a correlation between the received signal demodulated for each of the reception antennas and the synchronization subsymbol included in the received signal, and

the data reception method further includes, after the step of estimating the characteristics for each of the transfer paths, correcting a frequency of the received signal based on the estimated frequency error.

[8] The data reception method according to claim 7, wherein the step of correcting the frequency of the received signal includes:

calculating a frequency correction value for correcting the received signal, for each of the reception antennas, by weighted-averaging the estimated frequency error occurring in each of the transfer paths; and

correcting the frequency of the received signal based

on the calculated frequency correction value for each of the reception antennas, and outputting the received signal having the corrected frequency.

[9] The data reception method according to claim 7, wherein, in the step of estimating the frequency error, a received symbol timing is generated based on a weighted average of peak timings of correlation values between the received signal and the synchronization subsymbol included in the received signal.

[10] The data reception method according to claim 7, wherein the received signal includes propagation coefficient estimation symbols orthogonal to each other between each of the transmission antennas as symbols for estimating inverse functions of propagation coefficients possessed by the plurality of transfer paths between the transmission antennas and the reception antennas, and

the data reception method further includes, after the step of correcting the frequency of the received signal, estimating the inverse function of the propagation coefficient for each of the plurality of transfer paths based on the propagation coefficient estimation symbol included in the received signal having the corrected frequency, and based on the estimated inverse function, separating signals transmitted from the plurality of transmission antennas from the plurality of received signals.

[11] The data reception method according to claim 6, further comprising, between the synchronizing and demodulating step and the step of calculating the characteristics for each of the transfer paths,

estimating a frequency error included in the demodulated received signal for each of the reception antennas, based on a correlation between the received signal demodulated by the synchronizing and demodulating step for each of the reception antennas, and the synchronization symbol synthesized from the synchronization subsymbol included in the received signal;

calculating an average frequency error with respect to the plurality of received signals by weighted-averaging the estimated frequency errors; and

a second correcting step of correcting the frequencies of the plurality of received signals based on the calculated average frequency correction value.

[12] The data reception method according to claim 6, wherein the receiving step includes:

receiving the signals transmitted from the plurality of transmission antennas using reception antennas the number of which is larger than the number of the plurality of data sequences;

determining reception levels of the signals received by the larger number of reception antennas; and

selecting or combining the signals received by the larger

number of reception antennas, depending on the determined reception levels.

[13] The data reception method according to claim 6, wherein, in the synchronizing and demodulating step, in order to achieve synchronization between the plurality of reception antennas, a single reception local oscillator common to the reception antennas or a plurality of reception local different among the reception antennas, are used

[14] The data reception method according to claim 6, wherein the step of estimating the characteristics for each of the transfer paths includes estimating rough frequency characteristics for each of the transfer paths by interpolation of phases and amplitudes of the plurality of subcarriers included in the received signal, based on the synchronization subsymbol included in the received signal demodulated for each of the reception antennas, and

the method further comprises, after the step of estimating the characteristics for each of the transfer paths, estimating inverse functions of propagation coefficients possessed by the plurality of transfer paths based on the estimated rough frequency characteristics of each of the transfer paths, and separating signals transmitted by the plurality of transmission antennas from the plurality of received signal based on the estimated inverse functions.

[15] A data transmission apparatus of transmitting a plurality of data sequences from a plurality of transmission antennas to a plurality of reception antennas using MIMO-OFDM, the apparatus comprising:

a plurality of synchronization subsymbol generating sections of dividing a synchronization symbol in which predetermined amplitudes and phases are assigned to a plurality of subcarriers spaced at predetermined frequency intervals, into the plurality of transmission antennas, to generate a plurality of synchronization subsymbols which are orthogonal between each of the plurality of transmission antennas;

a plurality of modulation sections of modulating the plurality of synchronization subsymbols for the respective transmission antennas; and

a plurality of transmission antennas of simultaneously transmitting signals modulated by the plurality of modulation sections.

[16] A reception apparatus of receiving a plurality of data sequences transmitted from a plurality of transmission antennas using MIMO-OFDM, via a plurality of reception antennas, wherein

the plurality of data sequences include synchronization subsymbols generated by dividing a synchronization symbol composed of a plurality of subcarriers orthogonal to each other for each

of the plurality of transmission antennas,

the apparatus comprising:

a plurality of reception antennas of receiving the plurality of data sequences;

a plurality of demodulation sections of synchronizing and demodulating the data sequences received by the plurality of reception antennas for each of the reception antennas;

a plurality of synchronization subsymbol correlation sections of estimating a frequency error included in a received signal demodulated for each of the reception antenna from a correlation between the received signal and the synchronization subsymbol included in the received signal, for each transfer path; and

a plurality of frequency correcting sections of correcting a frequency of the received signal based on the estimated frequency error for each of the plurality of reception antennas.